



# Development and Application of Low-Carbohydrates and Low-Simple Sugar Nutrition Education Materials for Non-Alcoholic Fatty Liver Disease Patients

Yoo-Min An<sup>1</sup>, Dae Won Jun<sup>2</sup>, Seung Min Lee<sup>1\*</sup>

<sup>1</sup>Department of Food and Nutrition, Sungshin Women's University, Seoul 01133, Korea  
<sup>2</sup>Department of Internal Medicine, Hanyang University College of Medicine, Seoul 04763, Korea

We developed nutrition education materials for non-alcoholic fatty liver disease (NAFLD) patients focusing on low-carbohydrate and low-simple sugar diet and assessed subjective difficulty and compliance for the developed materials. The materials were developed in 2 types, a booklet for face-to-face education and a handout for phone education. The booklet covered 4 topic areas of fatty liver, low-carbohydrate and low-simple sugar diet, weight control, and meal plan. The handout material included several eating behavior tips. To assess practical usability of nutrition education using the developed materials, subjective compliance and difficulty levels were examined in a sample of NAFLD patients. A total of 106 patients recruited from 5 general hospitals were randomly assigned to a low-carbohydrate and low-simple sugar weight control diet group or a general weight control diet group. Each participant received a 6-week nutrition education program consisting of a face-to-face education session and two sessions of phone education. The developed materials were used for the low-carbohydrate and low-simple sugar weight control diet group and general weight control information materials were used for the control group. Subjective difficulty and compliance levels were evaluated three times during the education period. Subjective difficulty level was significantly higher in the low-carbohydrate and low-simple sugar diet group compared to the control group at the end of the second week, but such a discrepancy disappeared afterward. No significant difference was found for subjective compliance between the groups at each time. In conclusion, the developed nutrition education materials for low-carbohydrate and low-simple sugar diet are reasonably applicable to general Korean NAFLD patients.

**Key Words:** Non-alcoholic fatty liver disease, Low carbohydrate, Sugars, Diet

\*Corresponding author Seung Min Lee

Address Department of Food and Nutrition, Sungshin Women's University 55 Dobong-ro 76ga-gil, Kangbuk-gu, Seoul 01133, Korea

Tel +82-2-920-7671 Fax +82-2-920-2076

E-mail [smlee@sungshin.ac.kr](mailto:smlee@sungshin.ac.kr)

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## Introduction

Non-alcoholic fatty liver disease (NAFLD) is a disease that the fat sticks within the liver, though a patient doesn't excessively drink alcohol [1]. NAFLD is closely related to abdominal obesity and insulin resistance syndrome [2]. As the prevalence of insulin resistance syndrome and obesity increases, NAFLD tends to increase globally [3-5]. According to the report of Korea Food and Drug Administration

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in 2012, prevalence of NAFLD in Korean adults is rapidly increasing with 11.5% in 2004 and 27.3% in 2010.

According to the two hits hypothesis, NAFLD development is explained as the inflammatory response from oxidative stress and lipid peroxidation and the lipid accumulation in the liver due to insulin resistance [6,7]. It has been reported that people in Asian countries show higher NAFLD prevalence at similar body mass index level compared to people in Western countries, and it is attributable that NAFLD development is related to genetic factors as well as eating habits [8-10].

So far weight-loss is most emphasized method among NAFLD treatments. Fat adherence degree in the liver showed favorable results when the patient lost weight [11,12]. To decrease fat accumulated in the liver 3-5% of weight loss is required, and over 10% of weight loss and gradual weight loss over 6 months is recommended to attenuate inflammation in the liver [13,14]. The fact that ingestion of high-fat diet causes fat accumulation within the liver tissue has been observed [15] and saturated fat intake in NAFLD patients raised insulin resistance and oxidative stress in the serum [16].

One point that should be paid attention with regard to dietary factors of NAFLD is carbohydrate and simple sugar consumption. Intake of food with high carbohydrate content stimulates insulin secretion. Also, increase of insulin influences generation of fatty liver by inducing fat synthesis in the liver [17]. Kang et al. [18] investigated inflammation degree of liver tissue according to macronutrient energy intake rate among patients with both fatty liver disease and insulin resistance syndrome and observed more severe inflammation degree among those with higher energy intake ratio from carbohydrate. In addition significantly positive correlation was reported between abnormal aminotransferase activation and insulin resistance syndrome for those with carbohydrate energy intake rate over 70% while no meaningful relation was found among those with high fat intake [19].

Effect of low-carbohydrate diet has been reported by several previous studies. When NAFLD patients have low-carbohydrate diet, alanine aminotransferase (ALT) and fat accumulation in liver decreased [20]. Haufe et al. [21] who conducted a random clinical trial comparing low-carbohydrate diet and low-fat diet reported that fat amount in liver decreased in both groups. On the contrary, patients with over 54% of energy intake from carbohydrate showed

6.5 times higher incidence of fatty liver inflammation compared to patients with below 35%. Interestingly, those with high fat intake displayed a lower level of inflammation in liver [22]. Furthermore several studies showed that low-carbohydrate diet was more effective than low-fat diet in managing obesity and insulin resistance syndrome [23-25].

Simple sugar, particularly fructose, appears to have close relation with the incidence of NAFLD. Excessive fructose intake may cut off fatty acid oxidation process by rapidly generating citrate in liver and increasing malonyl-CoA. As a result increased free fatty acid in liver is accumulated as triglyceride [26]. Bergheim et al. [27] reported that fructose caused liver inflammation by increasing the number of intestinal virus and toxin inflow through hepatic portal vein. Along with the increase of beverage consumption including high fructose corn syrup, incidence of NAFLD and liver tissue fibrilization of NAFLD patients also increased [28,29].

According to 2011 Korean National Health and Nutrition Examination Surveys, average carbohydrate intake was as high as about 322 g/day [30]. Average energy intake proportions from carbohydrate and fat were 65.8% and 19.6%, respectively. Compared to Americans' diet, Koreans' energy intake from carbohydrate is markedly higher while energy intake from fat is lower [31]. Therefore weight loss approach applying reduction in carbohydrate intake can be effective for NAFLD treatment in Koreans. Clear NAFLD medicine has not been developed so far. Recently genetic factors such as patatin-like phospholipase domain-containing protein 3 (PNPLA3) were reported to have close relation with fat adhesion in liver, but genetic treatment development is insufficient. Accordingly, weight loss by modifying diet is recommended as the best method for managing and treating NAFLD [32]. It is important for NAFLD patients to continuously manage diet by themselves in daily life, because patients are mostly outpatients rather than inpatients. Positive effects of nutrition education on patients' self-efficacy has already been reported through several domestic studies [33-35]. While there have been several studies regarding that nutrition education is effective in treatment of certain diseases [36-38], research on concrete development of nutrition education material for NAFLD patients has been scarce. Recently Korean Association for the Study of the Liver presented 'clinical practice guidelines for non-alcoholic fatty liver disease'. The guidelines recommended low-carbohydrate and low simple-sugar diet education along with overall energy intake reduction to NAFLD pa-

tients [39]. Therefore this research aimed to develop nutrition education materials for NAFLD patients focusing on low-carbohydrate and low-simple sugar diet and examine practical applicability of the developed materials.

## Materials and Methods

### Development of educational material

The overall purpose of this educational material is 'desirable diet of NAFLD', targeting male and female adults in the age of 20-60 year-old. We aimed at developing materials for low-carbohydrate and low simple-sugar diet that is effective in weight control and can minimize triglyceride adhesion to liver [39,40]. This research intended to develop a material optimized for the individual interview education and the telephone education, currently utilized mainly by many hospitals as the educational method for outpatients. Education materials were developed in two forms: a booklet form with relatively much content for individual interview education [41] and a handout form for telephone education to follow-up outpatients who are difficult to frequently visit a hospital. Overall process of educational material de-

velopment is displayed in Figure 1.

The materials were designed to cover a total of 5 major themes and 3-4 sub-themes for each major theme (Table 1). The major themes included understanding of fatty liver disease, understanding of low-carbohydrates and low-simple sugar diet, importance of weight control, meal plan, and tips for eating behaviors. The booklet for face-to-face education included all the major themes except for the 'tips for eating behaviors' to help acknowledge basic relation between NAFLD and diet and crucial dietary modification issues. The handout for phone-mediated education was designed to cover the major theme of 'tips for eating behaviors'.

### Application of educational materials

#### Subjects

To assess practical usability of nutrition education using the developed materials, subjective compliance and difficulty levels were examined in a sample of NAFLD patients. A total 106 patients recruited from 5 general hospitals in Seoul, Chuncheon, and Cheonan were randomly assigned to a low-carbohydrate and low-simple sugar weight control diet group or a general weight control diet group. The inclusion criteria included NAFLD diagnosis by abdominal ultrasonic waves or computed tomography (CT) scan within recent 3 months, ages between 20-60 year-old, ALT or AST over 40 U/L before treatment, and usual alcohol consumption lower than 140 g/week for males and 70 g/week for females, no use of special dietary or physical activity regimen and insulin therapy, and body mass index less than 35 kg/m<sup>2</sup>. The study was conducted between April and October, 2012. Overall process of the research was approved by the institutional review board (HYUH IRB 2012-C-09 of Hanyang University Hospital).

#### Data collection

Each participant received a 6-week nutrition education program consisting of a face-to-face education session and two phone education sessions (Figure 2). The developed materials were used for the low-carbohydrate and low-simple sugar weight control diet group and general weight control information materials were used for the control group. Before the first education session, data on age, weight, height waist circumference, and blood pressure were collected. Waist circumference was measured around the navel with a tape measure and blood pressure was measured with the blood

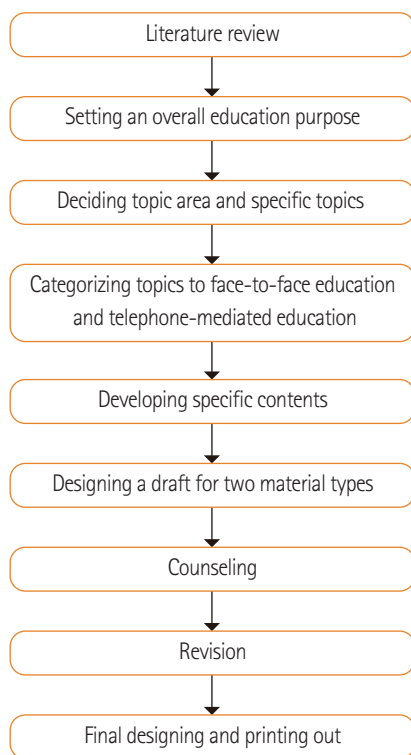
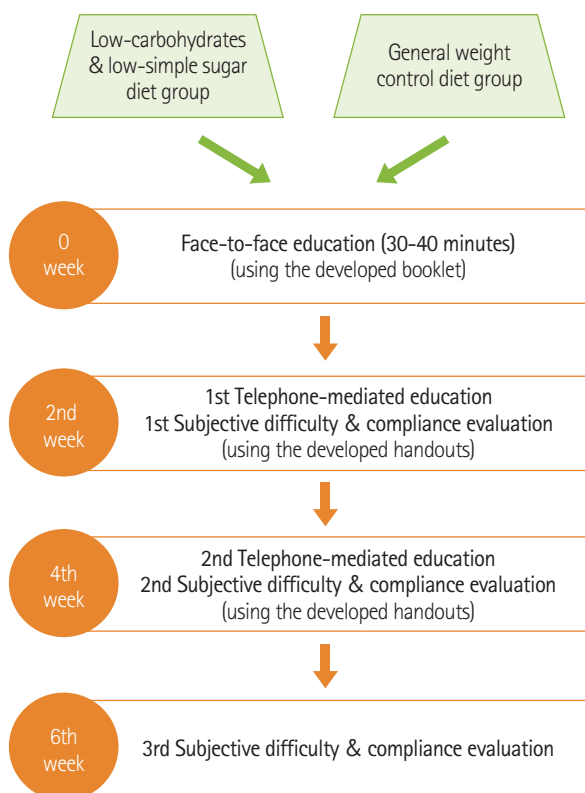


Figure 1. Flow chart of nutrition education material development.

**Table 1.** Composition of nutrition education materials

Major theme	Sub-theme	Type
Understanding of fatty liver disease	Basic knowledge of fatty liver disease	Booklet for face-to-face education
	Relation between fatty liver disease and eating behaviors	
	Risk of fatty liver disease	
Understanding of low-carbohydrates and low-simple sugar diet	Definition of low-carbohydrates and low-simple sugar diet	
	Adequate energy intake	
	Carbohydrate intake and body fat accumulation	
Importance of weight control	Effects of weight loss to liver function	
	Calculation of body mass index	
	Estimation of individualized daily energy need	
Meal plan	Food serving size chart	
	Recommended food group intake pattern	
	Examples of daily meal plan	
Tips for eating behaviors	Healthy choice for low-simple sugar diet	Handout for phone-mediated education
	How to read nutrition facts label	
	Simple sugar amount in some snacks, beverages and fruits	
	Recipes for dressings low in simple sugar	



**Figure 2.** Application process of nutrition education materials.

pressure gauge after 5 minutes rest. Subjective difficulty and compliance levels were evaluated three times (2nd week, 4th week, and 6th week of nutrition education) during the education period. Both subjective levels of difficulty (1: very easy, 6: very difficult) and compliance (1: not comply at all, 6: comply very much) were evaluated using 6-point Likert-scale.

**Statistical analysis**

All statistical analysis was conducted utilizing SAS 9.2 version (statistical analysis system, SAS Institute, Cary, NC, USA). Data were described with means and standard deviations. Comparisons between low-carbohydrate and low simple-sugar diet education group and general weight control education group were analyzed with student t-test. Significance level of all statistical verification was 0.05.

**Results**

**Development of booklet for face-to-face education**

A booklet was developed in a total 9 pages of B5 size paper excluding the front and the rear cover, and titled as ‘Fatty liver, how can we eat?’ The font sizes of 20, 15, and 12 were used for the title, sub-title, and text, respectively (Figure 3).

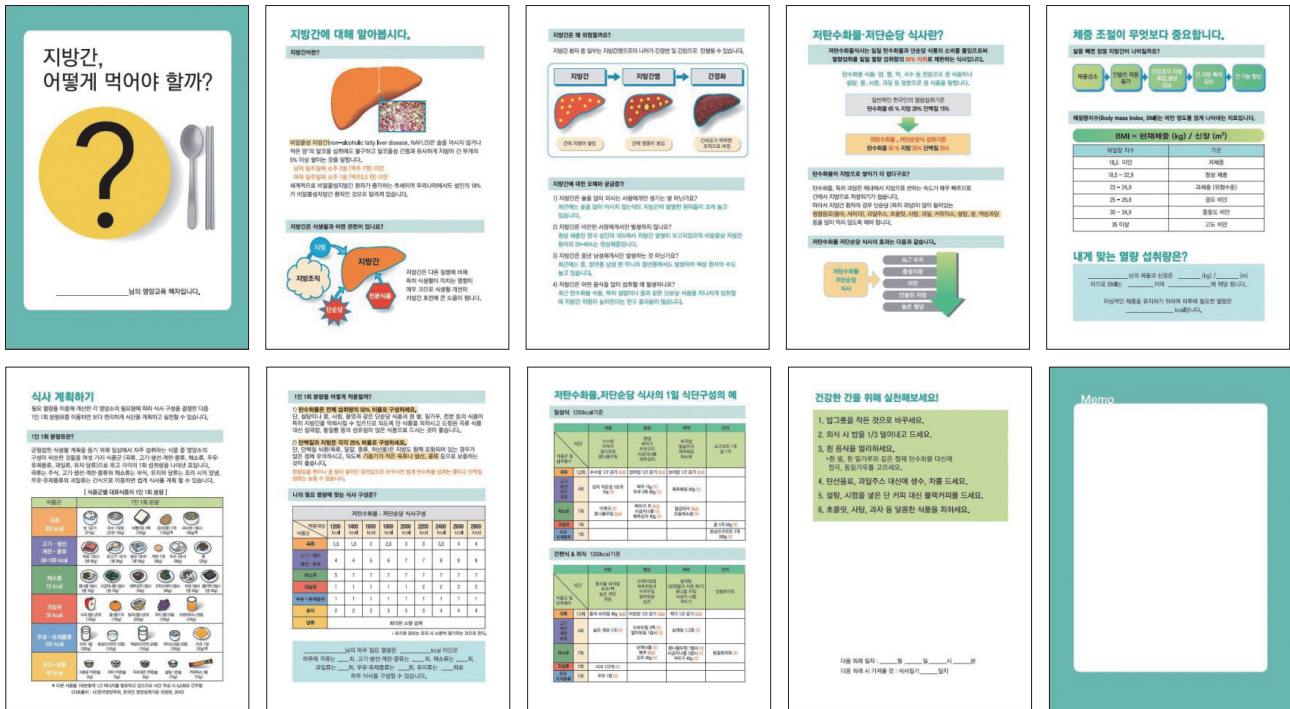


Figure 3. Booklet for face-to-face nutrition education.

1) 'Let us learn about the fatty liver'

The first two pages of the booklet briefly explain definition and seriousness of fatty liver, the relation between diet and fatty liver, and issues on misunderstanding and curiosity of fatty liver. Simple sugar and starch are emphasized as risk factors of fatty liver, besides fat, using visual images.

2) 'What is a low-carbohydrate and low-simple sugar diet?'

Page 3 presents effects of low-carbohydrate and low-simple sugar diet in relation to fatty liver disease. It introduces the concept of low-carbohydrate and low-simple sugar diet, high carbohydrate food items, the mechanism through which carbohydrate, particularly fructose, can easily accumulate in the body, and multiple advantages of low-carbohydrate and low-simple sugar diet.

3) 'Importance of weight control'

Page 4 begins with the reason why normal weight maintenance is important for NAFLD patients [11]. Information on how to calculate body mass index, how to assess obesity using body mass index, and how to estimate his/her own energy intake required for achieving healthy body weight subsequently follows.

4) 'Meal plan'

Page 5 and 6 suggest practical information that can be referred to plan balanced diet for required calorie intake. A portion size for each of major food items across 6 food groups was introduced with the corresponding food figure, and recommended daily food group consumption patterns based on low-carbohydrate and low-simple sugar diet were presented across calorie intakes from 1,200 kcal/day to 1,800 kcal/day.

Page 7 presents an example of daily menu plan of low-carbohydrate and low-simple sugar diet. The menu plan for a day was suggested as two types, a 'traditional Korean diet' and a 'convenient & dining-out diet' to reflect various dietary characteristics.

5) 'Behavior guides for healthy liver'

Page 8 suggests 5 eating behavior guidelines to reduce carbohydrate and simple sugar intake. The suggested guidelines are as follows: ① Change your rice bowl into a small one; ② Take out a third of rice when eating out; ③ Avoid white foods such as white rice, white flour, and white table sugar; ④ Drink mineral water, black coffee, and tea instead of carbonated drink, fruit juice and coffee with sugar or syrup; ⑤ Avoid sweet foods such as chocolate, candies, and cookies.

### 건강한 간을 위한 현명한 식품 선택

단순당이 적은 식품을 선택하세요.

피해야 할 식품	대체 식품
<b>곡류</b> 흰 쌀밥, 떡, 갈비, 국수, 카이로 드식, 비스킷, 쿠키	현미밥, 김국밥, 통밀빵, 브리 빵
<b>당류</b> 설탕, 꿀, 사탕, 꿀 초콜릿, 알콜 함유 탄 과자	소량의 올리고당, 대체감미료
<b>우유, 유제품</b> 레유, 우유, 바나나우유, 아이스크림, 생크림	원 우유
<b>음료수</b> 카페인스, 콜라, 과일주스	생수, 맑은 차, 아이스커피, 얼두커피 (시럽제외)
<b>와사물 할 때</b> 편육 (가공한 소시지, 국수), 분식 (현미, 순두부), 부추김치 (매일, 김치냉장), 달걀말이 소스와 함께 먹는 음식 (탕수육, 닭강정)	비빔밥, 현미 백반, 닭강정, 회덮밥, 안성스테이크, 생버섯 (드레싱에 우유) 채소야채 (생과일은 적당량), 생선으로 (구이, 찜, 조림)

단순당이 많은 과일주스나 과일농축조제품보다는 **생과일**을 먹는 것이 더 바람직합니다.

단, 심혈관질환이 없다면 저지방에 중점을 두어 **적당량(약 100g)을 1일 1회-2회** 드시는 것이 좋습니다. 또한, **비교적 과당이 적은 과일**을 고르면 단순당 섭취를 줄이는데 도움이 됩니다.

<b>과당이 많은 과일</b> 사과, 바나나, 감, 키위, 브로콜리, 파인애플, 망고 등	<b>과당이 비교적 적은 과일</b> 토마토, 딸기, 수박, 자몽, 배, 등
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### 영양성분표 읽는 습관을 들여보세요

영양성분표와 식품 원료를 꼼꼼히 살펴보고 당류 함량, 설탕 또는 액상과당에 유의하세요.

"식품 포장지 뒷면에는 식품의 영양정보가 제시되어 있습니다."

식품 포장지의 전체 내용을 확인하세요

가정장이 있다면 유의!

식품에 들어있는 당의 함량을 나타낸 것입니다.

한국 성인에 하루 당 섭취 권장량은 50g 이하이지만, 저지방 제품의 경우 **과일맛** 첨가 드시는 것이 좋습니다.

사탕 5개	케이크 1조각	탄산음료 500ml	유제품 1개
20g	14g	26g	25g

당류만 간식에서 들어있는 단순당 함량

콜라 1캔을 마시면 하루에 필요한 단순당을 모두 섭취한 것이나 다름 없습니다.

단순당 섭취를 줄이기 위해서는 단맛이 나는 카콜스, 탄산음료, 과일주스 대신 가공이 덜 된 자연식품을 선택하세요.

### 알아두면 유익한 영양 상식

◆ 지방간에 악영향을 끼치는 액상과당

◆ 무가당 주스는 안심하고 마셔도 될까요?

◆ 설탕 대신 올리고당 / 꿀라 대신 다이어트용과라? 마늘맛 먹어도 될까요?

◆ 가능한 설탕을 하지 않는 것이 좋지만, 부족한 경우에는 '덜덜' 음료수를 선택합니다.

### 단순당이 적게 포함된 샐러드 드레싱 레시피

◆ **비타민D 드레싱**  
레몬즙(레몬식초) 3큰술, 올리브오일 3큰술, 다진 마늘 0.5큰술, 다진 양파 1큰술, 파슬리카를, 소금, 후추 약간씩

◆ **향신료 드레싱**  
다진 마늘 1큰술, 참 3큰술, 마요네즈 1큰술, 다진 마늘 0.5큰술, 다진 양파 0.5큰술, 참깨 0.5큰술

◆ **향신료 드레싱**  
간장 1.5큰술, 참 3큰술, 다진 양파 1큰술, 다진 마늘 1큰술, 올리브오일 1큰술, 참깨 1큰술

◆ **고추장 드레싱**  
간장 1.5큰술, 레몬식초 1큰술, 참 2큰술, 다진 양파 1큰술, 올리브오일 1큰술, 고추장(액상제) 0.5 작은술

◆ **오이 토마토 드레싱**  
잘게 썬 오이 1/3개, 잘게 썬 토마토 1/2개, 레몬즙 1큰술, 다진 양파 1큰술, 올리브오일 1큰술, 파슬리카를, 소금, 후추 약간씩

◆ 드레싱을 통해 만들면 적은 양만 먹게 되므로 칼로리를 낮추는 데 도움이 됩니다.

◆ 마요네즈는 같은 양의 올리브오일이나 콩기름, 견과류(참깨, 호두, 아몬드, 땅콩)로 대체할 수 있습니다.

◆ 꿀 대신 다시아 옥수를 사용하면 드레싱의 질감이 좋아집니다.

◆ 구운 커치나 버섯, 두부 등을 갈으면 새콤하고 맛있는 샐러드가 됩니다.

◆ 양상추, 오이, 토마토 같은 수분 많은 채소보다 브로콜리, 양배추, 당근 같은 단단한 채소가 보관기간이 오래 갑니다.

Figure 4. Handouts for telephone-mediated nutrition education.

Development of a handout for phone-mediated education

Phone-mediated education material was developed in a 4-page handout of A4 size (Figure 4). This material focuses on practical information directly applicable when selecting food items in daily life. The 'Seoul Namsan' font was used with 28 font size for title, 20 for sub-title, 12-14 for text, and 18 for emphasized text.

Page 1 shows foods that should be avoided, their substitution foods, and fruit items with relatively high simple sugar amount [43]. Page 2 explains how to read a nutrition label and a food ingredient list to cautiously select low-simple sugar food products. Also selection of natural foods rather than processed foods was emphasized [44]. The next page focuses on popular beverages high in simple sugar content, and the last page presents a total of 5 salad dressing recipes low in simple sugar.

Application of the developed educational materials

Subjects

A total of 106 subjects who participated in preliminary application of nutrition education using the developed materials were randomly assigned to either a general weight control diet group (N=54) or a low-carbohydrate and low-simple sugar diet group (N=52) (Table 2). No significant differences in age, weight, body mass index, waist circumference, blood pressure, and fasting blood glucose were observed between two groups, reflecting the random assignment was performed well.

Subjective level of difficulty and compliance

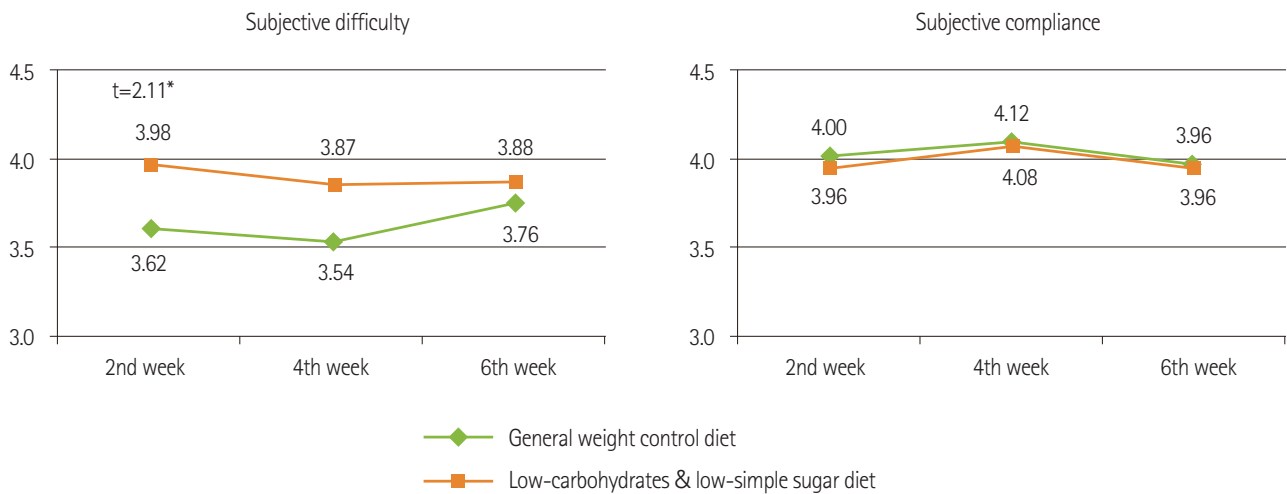
Figure 5 displays subjective levels of difficulty and compliance at the 2nd, 4th, and 6th week. Subjective difficulty level was significantly higher in the low-carbohydrate and low-simple sugar diet group compared to the general weight control group at the 2nd week (3.98±0.91 vs. 3.62±0.72, p=0.035),

**Table 2.** Basic characteristics of subjects

	General weight control diet (n = 54)	Low-carbohydrate & low-simple sugar diet (n = 52)	t-value <sup>†</sup>
Age, year	42.4 ± 13.0*	43.6 ± 11.8	-0.51
Weight, kg	76.6 ± 15.2	78.1 ± 17.3	-0.46
BMI, kg/m <sup>2</sup>	27.0 ± 3.9	27.3 ± 4.3	-0.32
Waist, cm	91.9 ± 10.9	93.1 ± 12.1	-0.52
Systolic blood pressure, mmHg	126.7 ± 14.8	126.1 ± 13.5	0.21
Diastolic blood pressure, mmHg	77.2 ± 11.2	76.6 ± 9.8	0.28
Fasting blood glucose, mg/dL	102.8 ± 21.2	103.8 ± 17.2	-0.26

\*Mean ± SD.

<sup>†</sup>By student t-test.



**Figure 5.** Comparison of subjective difficulty and compliance between the low-carbohydrate and low-simple sugar diet and the general weight control diet group. \*p < 0.05.

but such a discrepancy disappeared afterward. No significant difference was found for subjective compliance between the groups at each time.

## Discussion

This research developed nutrition education material for low-carbohydrate and low-simple sugar diet targeting NAFLD patients and evaluated the applicability by assessing subjective difficulty and compliance levels during the 6-week education period. One of the distinct characteristics of the developed materials is that they are based on low-carbohydrate and low-simple sugar diet which is apart from traditional Korean macronutrient composition. Fifty percent of calorie intake from carbohydrate was selected as a main purpose based on the recent domestic literatures [39,40,45]

and clear distinctness from general weight control diet. With regard to simple sugar intake, fruit intake once or twice a day was recommended to minimize consumption of added simple sugar. Another characteristic of the developed materials is that they were designed to be administered in an individual nutrition education setting. Specifically, the materials was designed to apply for compliance of daily energy requirement and daily food group consumption pattern for each recipient's own condition. Individually customized nutrition education was more effective in reducing fat intake and increasing fruit and vegetable intake compared to general nutrition education [46,47]. The subjective difficulty level was higher in the low-carbohydrate and low-simple sugar diet group compared to the general weight control diet group after the first education session. This may be due to relatively less familiarity of the low-carbo-

hydrate and low-simple sugar diet as a dietary regimen for NAFLD. While correlation between high fat intake and fatty liver is commonly recognized and widely known, the low-carbohydrate and low-simple sugar diet is not familiar to public. However, as the education continued, the degree of subjective difficulty showed no difference from the general weight control diet group. This implies that the low-carbohydrate and low-simple sugar education can be applied to Korean adults who usually take carbohydrate-based diet if education is given with proper intensity, method, and materials.

Both groups showed relatively high subjective compliance levels, with no difference between the groups. Such a finding implies an important meaning in respect that compliance to macronutrient modification diet is a strong predictable factor of weight control success [48]. A recent study reported that hyperglycemic diabetes female patients experienced improper blood glucose control when following low-fat diet [49]. Also a study comparing low-fat diet and low-carbohydrate diet found that insulin resistant participants showed lower compliance to low-fat diet compared to highly insulin sensitive participants. On the contrary, no significant difference in compliance degree for low-carbohydrate diet was observed between insulin resistant and insulin sensitive participants [50]. These findings can be interpreted that the patients with insulin resistance showed low compliance to low-fat diet due to their lower satiety level in case of low-fat diet. However, we observed reasonably high compliance degree in both groups despite subjects' fasting glucose level beyond the healthy range. This difference may come from, at least partly, a large gap in fat content of diet.

## Conclusion

This research developed educational materials focusing on low-carbohydrate and low simple-sugar diet and practical dietary method for Korean NAFLD patients. Findings from the application process of the developed materials and the patients' responses suggest that the developed nutrition education materials for low-carbohydrate and low-simple sugar diet are reasonably applicable to general Korean NAFLD patients. Further research to examine clinical effects of nutrition education for NAFLD patients using the developed materials is necessary.

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## Conflict of Interest

The authors have declared no conflict of interest.

## ORCID

Seung Min Lee <http://orcid.org/0000-0003-3046-8010>

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